193-00561

EOSDIS Core System Project

DCE Migration Study for the ECS Project

Working paper - Not intended for formal review or Government approval.

December 1993

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1. Introduction

The attached study addresses the rationale behind the selection of the Open Software Foundation's Distributed Computing Environment (OSF DCE) Services as the technical foundation for the ECS Enterprise Architecture. We believe that this selection is in harmony with the overall ECS criteria of risk mitigation and continuous improvement and will provide a superior distributed enterprise foundation over the entire ECS life cycle.

1.1 Study Overview

This study will provide a discussion of the following topics:

- Goal of an open and evolving enterprise foundation architecture
- Importance of Standards as a Risk Mitigation Strategy
- Overview of OSF DCE
  - Technical Overview of DCE
  - OSF Current and Future Plans Related to DCE
- Risk Assessment Analysis
  - Alternative Architectures
  - Other Risk Factors
  - DCE Risk Analysis
- Study Conclusions

In the interest of clarity and readability, footnotes have been used to document many of the statements made in this study. The footnotes often include a representative quotation so that the reader may gain more immediate insight into the substance of the reference. Although the footnote references are largely trade-press quotations, most have been confirmed through direct contact with the vendors and organizations quoted.

1.2 Goal of an Open and Evolving Enterprise Foundation Architecture

The Open Software Foundation Distributed Computing Environment has met both the basic and additional criteria that has been established for the ECS' goal of an open and evolving distributed enterprise architecture. These criteria are outlined in the following tables.

1.2.1 Basic Criteria for the ECS Distributed Enterprise Foundation Architecture

The basic requirements for the ECS Distributed Enterprise Architecture include widely accepted open systems definitions:

◗	An integrated computing environment consisting of components whose functions and interfaces comply with widely implemented, vendor-neutral standards
◗	An environment that provides interoperability, applications portability and scalability
◗	Very strong support for formal and de facto standards that will provide high levels of risk mitigation
◗	A distributed environment that provides a uniform set of services, across heterogeneous devices and platforms, anywhere in the enterprise network
◗	An environment that has broad industry support, which includes a number of shipping products on a number of platforms and operating systems

1.2.2 Additional Desired Criteria for the ECS Distributed Enterprise Architecture Foundation

Several additional desirable characteristics were also sought as ideal distributed enterprise architecture features:

◗	Capability to go beyond vendor-neutral support, proving both platform and operating system independence
◗	Capability to support a highly transparent, secure and reliable set of uniform services, providing access to all devices and services as if they were local
◗	Capability to evolve with new technologies with minimum to moderate impact on existing code

The Open Software Foundation Distributed Computing Environment meets all basic and additional criteria for an open system and a distributed enterprise architecture. In the following sections, we will examine DCE and its capability to fully meet both the basic and ideal criteria established for the ECS Distributed Enterprise Architecture. We will also examine in detail the factors that led us to this conclusion. Competing architectures and other risk factors will also be discussed.

2. Importance of Standards to Both the Vendor and Customer as a Risk Mitigation Strategy

Support for vendor neutral standards, and ideally platform and operating systems independent standards, are essential to providing interoperability, portability and scalability across a distributed heterogeneous enterprise. The formal standards bodies, such as IEEE and ISO, move very carefully but also very, very slowly. Many vendors and users have grown impatient with the glacier-like rate of formal standards processes. With downsizing, the need for distributed systems capabilities similar to those on non-distributed, legacy systems, are being demanded by many organizations. Vendors would also like to seize this opportunity to increase market share as customers are downsizing and considering platform changes. With the need to support highly complex and transparent interactions over heterogeneous[1] systems, a substantial standards foundation, either de jure or defacto, is needed to minimize the very substantial risks for both vendors and user organizations in committing to a large-scale enterprise architecture foundation.

The growth of industry consortia is a direct result of this impatience. OSF was the first major consortium to address vendor/platform neutral standards on which to base future distributed architectures. Some of the subsequent consortium efforts, such as ACE, were unsuccessful because they benefited specific vendors or did not benefit the industry at large[2]. The industry trade press has also tended to report more on disagreements and on who has not joined this or that consortium than on the very substantial agreement that has occurred recently.

OSF, X/Open and other vendor consortia[3] [4] have been successful because most major industry players have accepted the following realities:

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1 LAN Magazine, April 1993, Directory Assistance, Sara Radicati, Nina Burns, "Enterprise wide, heterogeneous networks are becoming the rule rather than the exception. These networks are significant corporate assets that provide a reliable infrastructure for new distributed applications that will be deployed over the next decade to streamline business processes."

2 UNIX Review June 1993 So COSE, but yet. (Common Open Software Environment organization), Andrew Binstock, "For many reasons, COSE is not ACE. Competitors unite for only two reasons: greed and fear. ACE was the product of greed. As a result, when things started to go wrong, the participants in ACE lost interest and drifted back to their respective technologies that were proven money-makers."

DEC Professional, May 1993, "Alliances in this industry endure when they offer technology that adds value to the market. Both company-specific alliances, like those DEC has made, and broader industry partnerships, like COSE, must meet this .standard. When they are simply defensive posturing, they fail, and rightly so -- as the ACE Consortium debacle so amply demonstrated."

3Open Systems Today, March 29, 1993, How some of the Prominent Unix Coalitions Have Fared, Laurel Nelson-Rowe and Paul Kapustra, "OSF - ...The biggest successes have had to do with Motif and the OSF's interoperability specifications, like DCE..."; "X/Open has been the most successful"; "ACE - an unequivocal flop".

4PC Magazine, August 1993, Middleware revealed: a new class of software is making distributed systems a reality. (Network Edition: Technology Spotlight), Jim Culbert; "STANDARDS Two consortiums, Open Software Foundation (OSF) and Object Management Group (OMG), are developing middleware standards. OSF is developing Distributed Computing Environment (DCE), and the OMG is developing standards for distributed object-oriented computing under the umbrella of the Common Object Request Broker Architecture (CORBA). Vendors and IS managers have been very enthusiastic about these efforts, but serious questions remain concerning whether these standards will become widely accepted."

Systems are becoming so complex that:

- No single vendor can provide all capabilities to all customers as was attempted with some success with most earlier Enterprise models.
  - No Operating System or Network Services vendor alone can provide the rich environment that comes from large numbers of third party vendors providing hardware, middleware, network services, development toolsets and applications.
- A level of standardization of basic services is needed for interoperabilty and communications so that each developer doesn't have to code yet another interface to this new device, Network Service, GUI, etc. Past lack of interoperability and portability has made it difficult for startups to address a broad enough market. [5]
- There is increasing need to make use of object-oriented technologies, to gain advantages of object reuse as well as to gain greater ease and flexibility of product enhancement that can be obtained with an object-oriented model. Object technologies offer much more flexibility with non-standard data models, such as images and sound, that are becoming more important in many business and government organizations. OSF has recently indicated that some Object-Oriented DCE capabilities are being worked on and that the subject is under review.[6] [7]
  - Object Technology is the principal strategic direction of:

    All major Operating System vendors [8]
    - IBM DSOM (Distributed System Object Management)[9]
    - HP's ORB Plus [10] [11]

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[5] LAN Magazine, April 1993, Directory Assistance, Sara Radicati and Nina Burns; "The Open Software Foundation (OSF) Distributed Computing Environment (DCE) provides a model for vendors to integrate proprietary directory services into X.500 or X.500-like directory services."

[6] Communications Week, Oct. 11, 1993; DCE to get Object Programming; Saroja Girishankar, "...the Open Software Foundation plans to bring object-oriented programming to the Distributed Computing Environment." ECS Note: "This announcement was later refuted by OSF. Object support is forthcoming, but not for release 1.1 or 1.2. CORBA integration will come sooner.

[7] OSF-RFC, RFC-48, August 1993, C++ Support in DCE RPC, "The OSF Distributed Computing Environment (DCE) provides the capabilities necessary to build an object-oriented distributed application."

[8] ECS note: Some vendors include object technology within the operating system kernel, while others, particularly vendors that adhere to standards such as POSIX, implement their object technology as a layer above the operating system. Although implemented differently, the strategic direction is still toward object technology.

[9] ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; Graphic entitled **Strategic Moves: "...**IBM's Distributed System Object Model runs only on OS/2 and AIX."

[10] ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; Graphic entitled **Strategic Moves: "...**HP's ORB Plus only runs on Unix."

[11] ComputerWorld, Sept. 27, 1993, HP offers full Corba implementation, finally, Melinda-Carol Ballou; "Hewlett-Packard Co. last week unveiled an implementation of the Object Management Group (OMG)'s Common Object Request Broker Architecture (Corba) that uses the Distributed Computing Environment (DCE) from the Open Software Foundation as its transport mechanism. ... HP is now combining DOMF with IBM's Distributed Systems Object Model to allow developers to create applications that are scalable, interoperable and portable across HP and IBM platforms. Both companies will comply with an interoperability standard for Corba that the OMG will establish in the first half of 1994." Graphic Text: "HP's ORB Plus uses DCE as its transport mechanism. It is integrated with DCE through DCE's Remote Procedure Call and Naming Services."

- Sun DOE (Distributed Objects Everywhere) [12]
- Novell NetWare DOMS (Distributed Object Management System - HyperDesk)[13]
- Microsoft Future NT (code-named Cairo) and OLE 2.0 [14]
- NeXT [15]
- DEC [16]
- Apple/IBM Taligent [17]

All-major Network Services vendors [18] [19]

All major DME-like Distributed Enterprise Systems [20]

Most Industry Consortia, in addition to OSF:

- X/Open [21]
- COSE [22]

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[12]ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; Graphic entitled **Strategic Moves:** " Sun's Project DOE ... run only on Unix."

[13]ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; Graphic entitled **Strategic Moves:** "Novell, Inc. will embed the Corba spec via HyperDesk Corp.'s Distributed Object Management System (DOMS) into a range of Novell operating systems. DOMS is also key to Novell's AppWare strategy."

[14]ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; "While Microsoft has pulled out the stops for Object Linking and Embedding (OLE) 2.0 and Cairo, its strategy for distributed, object-oriented computing ..."

[15] PC Magazine, Sept. 14 1993, Your next operating system?, Bill Machrone, "Compared to NeXTStep's highly evolved, object-oriented tools, the tools and APIs in other environments are woefully archaic."

[16]ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou, Graphic entitled **Strategic Moves:** " The Digital and HyperDesk [also used by Novell] implementations are set apart from the others by the greater range of operating systems on which they run. These include Windows, Macintosh, Unix and Digital's VMS, among others".

[17] PC Magazine, Sept. 14 1993, Your next operating system?, Bill Machrone, "By making the entire operating system object-oriented, Taligent expects to lay to rest the long-standing criticism that object orientation hurts performance."

[18]Distributed Computing Monitor, June 1993, The quest for management application integration: filling the gap in management architectures. (Network Management Watch), John Rymer, "The NM Forum (Bernardsville, New Jersey), the Open Software Foundation (Cambridge, Massachusetts), and others are working through a self-appointed task force called the Hilton Head Object Group (HHOG) to define a comprehensive set of common object definitions for management applications. The goal of this effort is to define a cross-platform information model for network and systems management applications."

[19]Corporate Computing, June 1993, A foundation for the future. (network management platforms) (Special Report: Network Management) (Buyers Guide), Jodi Mardesich, "Expect the architectures for these platforms to become more distributed and object-oriented."

[20] Network World, July 5 1993, Putting an end to the swivel shuffle, "The latest generation of management platforms is making the dream of integrated management of diverse local area networks (LAN) from a single workstation a reality. They do this by supporting the Simple Network Management Protocol (SNMP) as well as such new object-oriented management standards as the Open Software Foundation Inc's (OSF) Distributed Management Environment (DME) and the Network Management Forum's Open Management Interoperability Point (OMNIPoint)."

[21] Unix Review, Sept. 1992, Andrew Binstock, "The 1991 standard is called the Common Object Request Broker Architecture (CORBA). The ins and outs are specified in detail in the manual: CORBA Architecture and Specification, which is jointly published by OMG and X/Open."

[22] Open Systems Today, March 29, 1993, Coalition's Demo, "The [COSE] coalition will also develop standards for graphics and object-oriented applications."

- OMG [23]
- NM Forum [24]

Technologies such as Object Technology and Distributed Enterprise Architectures are certainly the focus of vendors, consortia and user organizations for future distributed enterprises. And although some of the standards needed for real-world implementation and integration of these technologies are being considered by the formal standards bodies, most are still being defined. The need for vendor and platform independent standards for distributed enterprise implementations are needed by both vendors and user organizations. This situation has created a new level of cooperation in the industry, as is illustrated by the number of organizations working on these issues and more importantly working with each other on these issues.

2.1 Cooperation Among De Facto Standards Organizations

In addition, these organizations, which may be characterized as de facto standards organizations, also have members active in the more formal standards bodies, such as ISO and IEEE. There is real cooperation and considerable convergence of standards in many critical technical areas from formal standards committees to recently formed consortia. One example is given below. This process is even more apparent with technologies related to the OSF DME architecture, which builds on the DCE foundation.

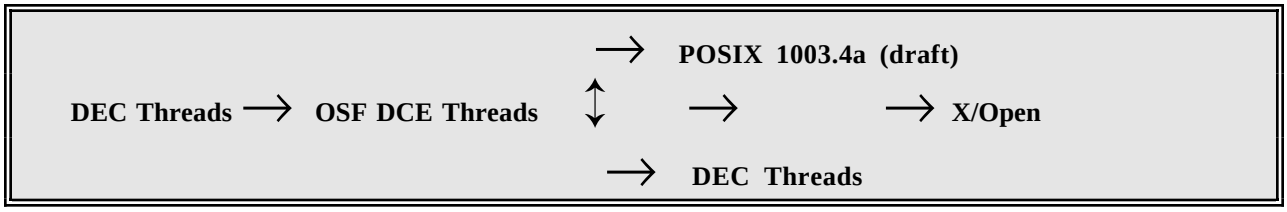

Figure 2-1. Standards Convergence Example

2.1.1 De Facto Standards Organizations and Consortia

While the more formal standards bodies, such as ISO and IEEE, may be familiar, the newer consortia, such as OSF, OMG, X/Open and COSE, may be less familiar. The goal of these organizations is to facilitate the acceptance and compatibility of critical de facto standards for distributed computing enterprise environments. All of these organizations use the accepted formal standards, including POSIX and OSI, as their reference foundation. There are however

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[23] ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou; "...the Object Management Group (OMG) will shift the way its object-oriented standard is determined."

[24] Network World, July 5 1993, Putting an end to the swivel shuffle, "The latest generation of management platforms is making the dream of integrated management of diverse local area networks (LAN) from a single workstation a reality. They do this by supporting the Simple Network Management Protocol (SNMP) as well as such new object-oriented management standards as the Open Software Foundation Inc's (OSF) Distributed Management Environment (DME) and the Network Management Forum's Open Management Interoperability Point (OMNIPoint)."

considerable missing pieces in the formal standards for an effective functional implementation of a distributed enterprise architecture.

Both vendors and users would like to be assured of minimum de facto standards before committing to something as significant as an enterprise-level architecture. The role of these organizations in defining de facto standards for the future distributed enterprise architectures are outlined below.

2.1.1.1 Open Software Foundation (OSF)

The OSF was formed in a Unix industry split between USL and Sun over Unix licensing. Although much initial focus was given to the development of an operating system (OSF/1) that did not use any USL Unix code, the OSF has evolved as the focus of the information technology paradigm shifted from the operating system to the distributed computing enterprise. Most observers acknowledge that DCE and the soon-to-be released DME are very significant contributions that OSF has made to industry as a whole.[25] As shown in Figure 2-2, the OSF has worked very closely with its vendor members, formal standards bodies and other consortia to achieve this level of consensus.

2.1.1.2 X/Open[26]

X/Open Company Ltd. was founded in 1984 as an international, independent organization dedicated to developing an open, multivendor applications environment. X/Open designed XPG (X/Open Portability Guide) as a vehicle for implementing open systems in the real world. XPG is an evolving portfolio of application programming interfaces (APIs), protocols, and other specifications that are supported with an extensive set of conformance tests. A distinct X/Open trademark is carried only on those products that comply with X/Open portability definitions. The latest release, XPG4, includes specifications covering interoperability and communications.

The X/Open's technical working groups draw on several sources--users, standards bodies, suppliers, and various consortia--to determine the specifications and ensure that they are aligned with relevant formal standards. When specifications are developed in advance of commercial implementations, they are first published as preliminary specifications. Only when the specifications have been tested and shown to be fully practical are they published as full X/Open specifications and used as the basis for branding. XPG3 is fully aligned with the IEEE Standard 1003.1-1988 (POSIX), while XPG4 is aligned with POSIX 1003.1-1990.

The X/Open XPG is widely used as an independent, open-systems procurement specification by governments and commercial organizations around the world.

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[25]Open Systems Today, March 29, 1993, How some of the Prominent Unix Coalitions Have Fared, Laurel Nelson-Rowe and Paul Kapustra, "OSF - ...The biggest successes have had to do with Motif and the OSF's interoperability specifications, like DCE...."

[26] Information adapted from article in UNIX Review, March 1993, Emerging standards. (X/Open's XPG4, Object Management Group's Common Object Request Broker Architecture and IEEE's POSIX.2 Unix standards) by Hal Jesperson

2.1.1.3 Object Management Group (OMG)[27]

The OMG (Framingham, Mass.) was founded in 1989 and currently has over 300 members. It is the least widely known of the four consortia outlined here. Nevertheless, OMG may be as important to future de facto standards for distributed computing as OSF is to the current de facto standards. OMG, like OSF, is working closely with standards organizations mentioned in this study and with other standards organizations, such as the Network Management Forum, to achieve the same kind of consensus as the OSF has built for DCE and DME. OMG's focus is object-oriented technology, and most especially object technology in a distributed, heterogeneous enterprise environment. Although distributed computing and object technology had been evolving along seeming unrelated paths, the combination of distributed computing and object-orientation provides extensible features and additional potential efficiencies to each technology. While this study will only reference this technology at a very high level, it is important to understand that there is nearly overwhelming industry consensus that OMG standards, chiefly the Common Object Request Broker Architecture (CORBA) is a major future standard for distributed computing. This strategic direction and the standards that will support this technology over heterogeneous, distributed environments must be considered in a risk mitigation plan.

2.1.1.4 Cooperative Open Systems Environment (COSE)

COSE, while not as important as the groups above, is in the process of unifying several important standards in the open systems environment. This organization, whose members include Sun, SCO, IBM, HP, USL and UI, represent 70%[28] of the installed Unix base. COSE is trying to clear roadblocks to interoperability and portability (as well as compete with Microsoft). Agreement to standardize on the Motif/X-Windows GUI will be a significant contribution to this goal. The group is also working other elements of a common desktop environment. Novell's recent turnover of the Unix trademark and specifications to X/Open will also help minimize platform differences and may be especially important to small third party vendors. Like OSF and OMG, COSE will have X/Open maintain and validate these specifications.

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[27] Information adapted from article in UNIX Review, March 1993, Emerging standards

[28] Open Information Systems, April 1993, Common Open Software Environment, M. Goulde, "One thing is certain: Even though the six Unix vendors represent over 70% of the Unix market, X/Open will not be railroaded into approving it."

The interaction of these consortia is illustrated as follows:

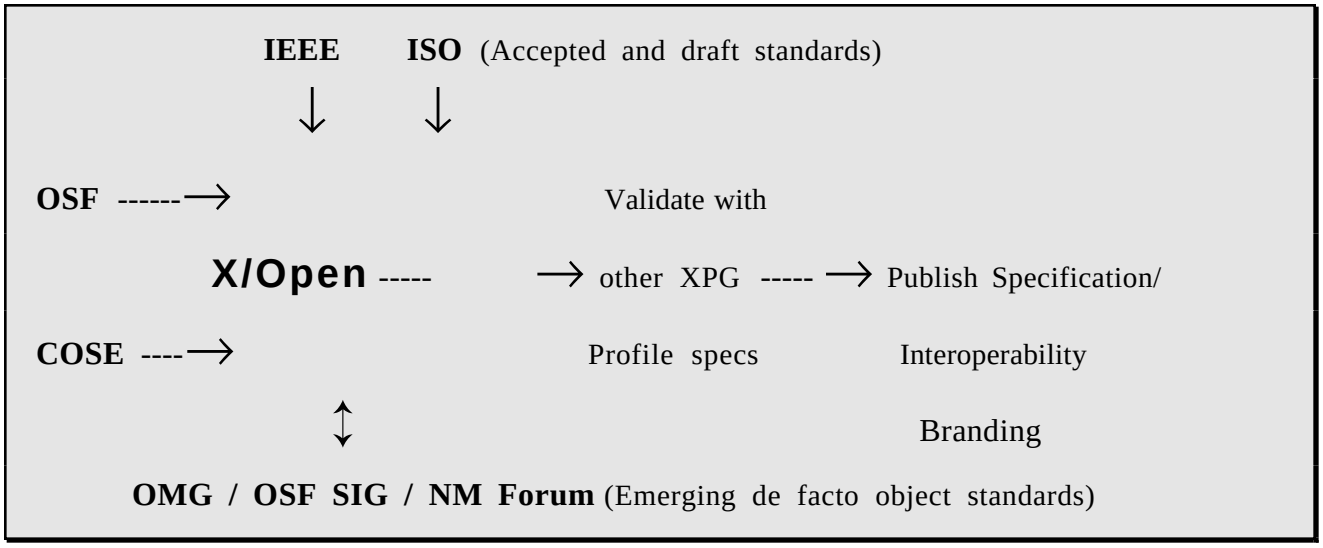

Figure 2-2. Cooperation Between Standards Organizations

3. Overview of DCE and the Open Software Foundation

This section will provide an overview of the technical components, or services, of the Distributed Computing Environment (DCE), and the Open Software Foundation's future plans and releases for DCE as well as its work with other standards groups and consortia. The following topics will be covered in this section.

- A Technical Overview of the OSF DCE Architecture
  - A brief overview of each of the DCE Core and Extended Services, including the integration between each of the DCE Services
- A brief overview of OSF DCE release status and future plans
- A brief overview of OSF's work with the standards process
- Overview Assessment

3.1 Technical Overview of the OSF DCE Architecture

The Distributed Computing Environment is composed of several highly-integrated components, or services as they are termed by the OSF. Unlike earlier monolithic architectures, the modular nature of the services is intended to provide a better mechanism to evolve technologies that comprise each service. This modular design minimizes the impact not only within the service which may be upgraded with a new technology, but also with other services that utilize the evolved or upgraded service. The Distributed Computing Environment provides a number of APIs to minimize direct coding to lower level network, transport and security services. These APIs also provide portability across vendor implementations and minimize the impact of future upgrades and enhancements to existing applications.

OSF's Distributed Computing Environment functions as a layer between the operating system and the distributed application. DCE provides the core and extended services that allow a distributed application to interact with a collection of heterogeneous computers, operating systems and networks as if they were a single system. DCE provides a platform- and vendor-independent distributed Enterprise Architecture.

Several technology components work together to implement the DCE layer, as illustrated in Figure 3-1.[29] The five core service components provided by the DCE architecture are DCE Threads, DCE Remote Procedure Call (RPC), DCE Directory Services (DS), DCE Distributed Time Service and DCE Security Service. The two extended services include DCE Distributed File Service (DFS) and DCE Diskless Support Service. (DCE Diskless Support Service is not depicted in Figure 3-1). These services provide a scalable, single-system or enterprise access across the network.

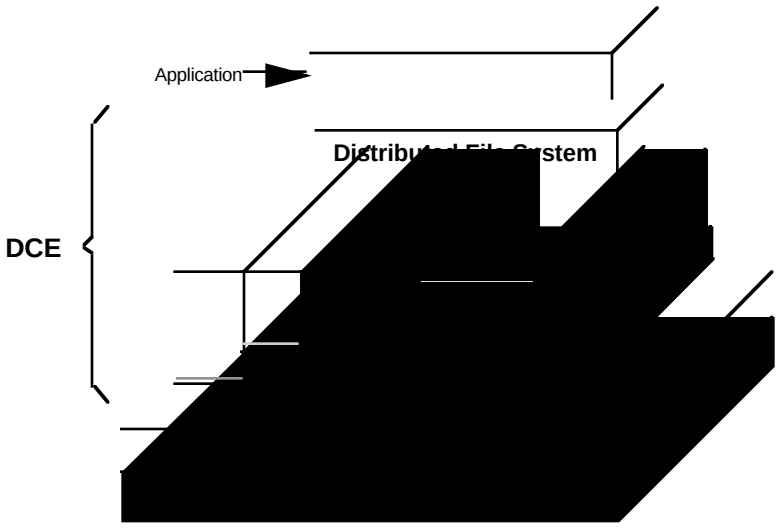

Figure 3-1. The OSF DCE Architecture

The five core and two extended DCE services are outlined below with a discussion of the integration of these services in the overall DCE architecture. The functionality of these services, especially as they are important to the overall ECS Enterprise Architecture and Project Mission, are outlined below. The vendors contributing to major portions of the original base DCE service are also mentioned identified, as are the standards with which the services and/or their APIs comply.

[29] ECS Note: The DCE technical descriptions that follow are adapted from several texts, including DCE Technical Manuals

3.1.1 DCE Threads

DCE threads is a user-level (non-kernel) library based on the Pthreads interface specified by POSIX 1003.4a draft specification. Threads service is provided for operating systems that do not support threads or it can be mapped directly to an existing threads facility provided by the host operating system. Threads, which are sometimes described as light-weight processes, provide a mechanism to enhance performance for many operations. DEC submitted the original base threads technology. OSF subsequently modified this submission to align with POSIX 1003.4a draft standard and DEC has done likewise.

3.1.2 DCE Remote Procedure Call (RPC)

The DCE Remote Procedure Call (RPC) supports the client/server model for distributed processing. The DCE RPC is a facility for calling a procedure on a remote machine as if it were a local procedure. The RPC Service is composed of an Interface Definition Language (IDL) and its compiler, a Universal Unique Identifier (UUID) generator, and the RPC Runtime, which supports two RPC protocol implementations. One RPC protocol operates over connection-oriented transports, such as TCP/IP, and the other RPC protocol operates over connectionless transports such as UDP/IP.

The DCE RPC is integrated with the DCE Security Service component to provide secure communications. Integration with the DCE Directory Service is also provided, but programmers may also use the Name Service Interface (NSI) routines of the RPC API.

The DCE RPC services are transparent to the end user. The original base technology for the DCE RPC capabilities were submitted by HP and DEC.

3.1.3 DCE Directory Services (DS)

The DCE Directory Services are comprised of three parts:

- Cell Directory Services (CDS), which stores names and attributes of resources located in a DCE cell. CDS is optimized for local access and is replicated.
- Global Directory Services (GDS), which is a distributed, replicated directory service based on X.500.
- DCE Global Directory Agent is an intermediary between a cell's CDS and the “rest of the world,” referred to as "foreign" cells. These foreign cells must be registered with either an X.500 Directory Service or a Domain Name Service.

The X/Open XDS directory service API is used to access the Directory Service Components. XDS uses the X/Open Object Management (XOM) API to define and manage its information. Programmers are required to use this interface to make all Directory Service calls. DCE Directory Services provides a one time login that will enable access to services, for which the user has been granted access rights, across the enterprise transparently. The original base directory service technology was submitted by Siemens.

3.1.4 DCE Distributed Time Service

The DCE Distributed Time Services (DTS) is composed of several components, but its principal service is to keep clocks on different nodes synchronized. DTS also provides a way of keeping a synchronized notion of time reasonably close to the "correct" time by providing hooks to external time sources such as the Internet Time Protocol. The original base time service technology was submitted by DEC.

3.1.5 DCE Security Service

The extensive DCE Security Service consists of the Authentication Service, the Privilege Service, the Registry Service, the Access Control List (ACL) Facility and the Login Facility. All of these components interact to provide a secure distributed environment, which is of critical importance to the ECS architecture. These DCE Security Services are tightly integrated with the other DCE services, providing, among other capabilities, an authenticated RPC.

The DCE Authentication Service is based on MIT's Kerberos Network Authentication Service. The Kerberos API is used internally by DCE Security and is not exposed for use by the application programmer. HP also submitted technologies to the original base OSF DCE Security Service.

3.1.6 DCE Distributed File Service (DFS)

The DCE Distributed File Service is a distributed client/server application, built on the underlying DCE Services. It takes full advantage of both the lower-level DCE services (such as RPC, Security, and Directory) and the distributed computing system itself.

DFS capabilities include the ability to use more flexible authorization in the form of DCE Access Control Lists, the ability to replicate, backup and even move different parts of the file system without interruption in service, as well as fast recovery, after a crash, made possible through logging. Transarc (Pittsburgh PA) submitted the Andrew File System technology originally developed at CMU as the base distributed file service technology.

3.1.7 Diskless Support Service

The DCE Diskless Support Service enables nodes without disks to participate in a DCE environment. The Diskless Support Service was submitted as original base technologies by Transarc and HP. (This service may not be used in ECS).

3.1.8 Integration of DCE Services

The DCE Services are modular so that they may be more easily evolved and adapted than a single monolithic architecture. The DCE Core Services are however highly integrated. DCE provides capabilities for programmers to integrate the DCE RPC and DCE Threads in applications that are capable of utilizing the DCE services, including DCE Distributed File Services, DCE Timing Services, DCE Directory Services and DCE Security Services.

Table 3-2, shown below, presents the high level of integration between these DCE services. An **X** indicates that a DCE service is integrated with the DCE service to its left.

	DCE Services Utilized---------->							
BY	**Threads**	**RPC**	**CDS**	**DTS**	**Security**	**GDS**	**DFS**	**Diskless**
Threads	NA							
RPC	X	NA	X		X			
CDS	X	X	NA	X	X	X		
DTS	X	X	X	NA	X			
Security	X	X	X	X	NA			
GDS			X			NA		
DFS	X	X	X	X	X		NA	
Diskless	X	X	X				X	NA

Table 3-1. Integration Between DCE Services Components[30]

3.2 OSF DCE Release Status and Future Plans

The Open Software Foundation has work progressing in several areas, including plans for a new DCE release, work on DCE future releases, work with other standards organizations and consortia on further directory services integration, object management, as well as interoperability testing and validation. These projects are briefly outlined below.

3.2.1 Current Release

- Current Release: 1.0.2, supporting all DCE services above.
- A Challenge '93 Event was held by the OSF to demonstrate the inter-operability of existing DCE releases. Interoperability with at least two other vendors platforms in both a client and server mode was required for participation[31]. The twenty-four vendors, listed below, demonstrated either interoperability or portability using OSF technologies on more than 80 different platforms, ranging from PCs to mainframes[32].

Digital Equipment Corp.	Alsys (formerly Telesoft)
Hewlett Packard Co.	Santa Cruz Operation
IBM Corp.	ICS
Groupe Bull	IXI Ltd.
Siemens Nixdorf Info. Systems	Intraco Systems
NCR Corp.	Interleaf
Stratus Computer	Gradient Technologies
Pyramid Technology	Transarc Corp.
Unix System Laboratory	Non Standard Logics
Oracle Corp.	S.I. Systems

[30] Adapted from chart provided with OSF DCE documentation.
[31] Challenge 93 document provided by Open Software Foundation.
[32] Distributed Computing Monitor, June 1993, Michael Goulde; Open Software Foundation at Age Five.

Sybase	MITRE
Atrium Technologies	Ingres

- A similar conference is planned for next year.

3.2.2 Future Releases[33]

- Release 1.0.3 is about to be released, including a new IDL compiler for the RPC services, completion of the threads and XDS work, addition of CMIP protocol requirements to the OSI upper layers to facilitate DME OSI support, performance enhancements to DFS read and write system calls and other incremental enhancements
- Release 1.1 is projected to be available 3Q '94

  Release 1.1 features will include:

  (a) Addition of a DCE Audit Sub-System to strengthen security

  (b) A new command interpreter program, which will provide a common command syntax for several DCE administrative operations

  (c) OSF will develop a set of extensions to the daemons found on all DCE nodes to improve configuration management.

  (d) OSF will publish a set of guidelines for the use of CDS as an aid to managing ells, hosts and servers.

  (e) Enhancements to the IDL compiler provided in release 1.0.3

  (f) DCE internationalization

  (g) DCE Security enhancements

  (h) DFS performance improvements

  (i) Other enhancements under review

3.2.3 Major Standards Supported by DCE

DCE supports the current POSIX standard, 1003.1-1990. The work done on both DCE and DME is in complete alignment with POSIX draft specifications, 1003.2 (Shells & Utilities), 1003.4a (OS threads) and 1003.7 (System Administration). OSF has submitted several DCE service components to X/Open for inclusion in its XPG4 (X/Open Portability Guide, version 4) DCE has indicated it will continue to submit all DCE and DME specifications to this organization to assure real-world compatibility with other open systems standards and to provide interoperability validation all OSF technologies by an independent organization. OSF continues to work closely with OMG on Object Technology standards and issues which are considered critical to future distributed enterprise architectures, including DCE and DME. OMG is also planning to submit its specifications to X/Open and rely on X/Open for validation testing with other XPG standards and branding (X/Open's term for interoperability certification). OSF DCE also supports many widely accepted OSI standards, such as X.500.

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[33] OSF "DCE Program Status Update" October 1993, Doug Hartman, OSF

3.3 Overview of OSF's Continuing Work in the Standards Process

3.3.1 OSF DCE Validation Suites[34]

The OSF DCE RPC Validation Suite, the first in a series of validation suites to assure DCE interoperability between different platform implementations, is being finalized. Although OSF will not require a vendor to pass these certification suites before offering the products to the public, it will give ECS a potential tool to ascertain DCE interoperability conformance and to insist on conformance.

3.3.2 Inclusion in the X/Open XPG Specification[35]

OSF is submitting its AES (Application Environment Specification), which will include all OSF specifications, including DCE, to X/Open for inclusion in the XPG specifications. X/Open has reviewed the AES Time Services. Directory Services are currently under review by OSF members as well as X/Open. Security and threads AES sections will be sent for review by the end of 1993. The DFS AES material for submission to X/Open will be developed during 1994.

3.3.3 Continuing Work with Other Consortia in the Standards Process[36]

OSF, at the request of X/Open, is managing a group to specify an extensible architecture for integrating name/directory servers. This project, known as the Federated Naming Project, currently includes OSF, HP, SunSoft, Siemens Nixdorf Information Systems, IBM and Banyan, with additional project members expected. The output of this project will be an API specifying a programming interface suitable for use with directory servers which are used to compose a namespace at runtime, along with a protocol which can be exported by directories which wish to participate in the namespace. OSF plans to incorporate the Federated Naming API into future versions of DCE.

3.3.4 Object Oriented Special Interest Group (SIG)

The Open Software Foundation has established a Special Interest Group, which is commonly referred to as a SIG, to focus on future technologies related to DCE that will enhance the overall DCE enterprise environment. The DCE SIG is working with accredited standards groups and other consortia on furthering the acceptance of object technology standards and the work OMG is doing in this area. The OSF has established this SIG because of the importance of object technology to the evolution of distributed enterprise architectures to both user organizations and vendors. A close working relationship between OSF and other standards organizations and consortia is critical to keep standards for particular technologies compatible with all other standards related to distributed enterprise architectures.

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34 OSF "DCE Program Status Update" October 1993, Doug Hartman, OSF
35 OSF "DCE Program Status Update" October 1993, Doug Hartman, OSF
36 OSF "DCE Program Status Update" October 1993, Doug Hartman, OSF

3.4 Overview Assessment

3.4.1 DCE Provides an Advanced Architectural Foundation for a Distributed, Heterogeneous Enterprise Architecture

The high functional level of the DCE Services, including the Directory, RPC, Security and Distributed File Services, combined with the tight integration provided between all DCE Services, provides the most advanced foundation for a distributed enterprise architecture.[37] [38] [39]

3.4.2 DCE is an Open System

DCE supports the major "open systems" standards, such as POSIX, X/Open XPG as well as several OSI standards. DCE is the most vendor- and platform-independent distributed enterprise architecture available.

The OSF plans DCE interoperability validation suites through X/Open CAE and XPG specifications providing an independent interoperability validation process.

3.4.3 DCE is Capable of Evolving with New Technologies

OSF is also continuing work with formal standards organizations, other standards organizations[40] and consortia, providing a mechanism to evolve to new technologies. The OSF has established Special Interest Groups (SIGs) to work with other consortia on technologies critical to the future distributed Enterprise: Object Technology and Directory Services.

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[37] Distributed Computing Monitor, May 1993, Great Expectations (Editorial), John Rymer, "The degree of support among large user organizations for DCE and CORBA is truly amazing. In virtually all of the large commercial organizations we've examined during the last year, DCE and CORBA occupy prominent places in the corporate architectures guiding next-generation information systems. .... DCE is most attractive to users because it provides a robust remote procedure call (RPC) that supports transactional applications."

[38] Unix World, Feb. 1993, Rik Farrow, Tutorial [on DCE RPC], "Although Sun's RPC was designed to operate in a heterogeneous environment, other concerns weren't as important. DCE, for example supports six different levels of security. DCE also features another important component, Cell Directory Services, to handle connecting clients transparently."

[39] LAN Times, Oct. 18, 1993, DCE reaches its new frontier: The Real World, Peggy Watt, "Distributed Computing Environment (DCE) technology has evolved from an optimistic promise of interoperability to become - just this year - a coherent, delineated standard with both strong real-world support from a majority of industry players and room to grow."

[40] Distributed Computing Monitor, June 1993, The Quest for Management Application Integration, -- work with other standards groups -- NM Forum.

4. Risk Analysis and Migration Strategy

4.1 Alternative Architectures and Other Risk Factors Considered

The potential risks in selecting any technology come from a number of forces, including competing products, availability of applications able to take full advantage of the architecture, potential lack of acceptance of the architecture, and the dependence on a single source or organization to oversee these technologies. These factors have been considered before making the final foundation architecture selection for ECS. The analysis of the risk factors evaluated in making our final selection are outlined briefly below in two major categories:

- Competing Technologies
  - Sun's ONC+
  - Microsoft's NT Advanced Server
  - Novell's NetWare
- Other Risk Factors Considered
  - Functional levels provided by standards/API implementation
  - Dependence on OSF for solution stability
  - Slow acceptance and implementation of DCE

As indicated in the previous section, we consider that DCE is both a superior foundation architecture and will continue to gain acceptance throughout the industry as the de facto distributed enterprise computing foundation. However, as an addition risk mitigation step, we have constructed a timeline to review the validity of our selections. We will use this timeline to review our original assumptions concerning the risk factor and our current DCE implementation. If there are any negative trends, that is in contradiction of our risk mitigation assumptions, we will review the specific factor in the context of the affect this risk could have on the overall ECS architecture. The timeline analysis is outlined briefly after each of the risk factors discussions below. Appendix A summarizes the timeline for all identified risks.

4.1.1 Competing Distributed Enterprise Architectures

Three competing Distributed Enterprise Architectures were identified: SunSoft's ONC^{+}, Microsoft's NT Advanced Server, and Novell's NetWare. It should be noted that while SunSoft's ONC+ high-level architecture, similar to DCE's high-level architecture, is composed of a layer between the Operating System and Network Services, Novell's NetWare and to some extent Microsoft's NT Advanced Server distributed enterprise capabilities are embedded within the operating system. The following analysis therefore may make reference to operating system or operating system features. Although DCE is completely operating system independent (implementations currently exist for Unix, VMS, DOS, and others), Novell's NetWare and Microsoft's NT Advanced Server are highly operating system dependent. The operating systems

in Novell's and Microsoft's solutions are a major part of their respective distributed enterprise architectures and therefore must be introduced and considered in the following analyses.

4.1.1.1 SunSoft's Open Network Computing (ONC+)

Over the years, Sun's Network File System (NFS) has become an industry standard for shared file services over many popular platforms. A few years ago, Sun also integrated NFS with the NIS+ (Network Information Service) directory services. NFS+, NIS+ and other utilities comprise Sun Microsystem's ONC+ (Open Network Computing). The ONC+ components are Sun's foundation architecture for its vision of the distributed enterprise. ONC+ is a competing distributed enterprise architecture with DCE. A risk assessment for this competing architecture follows.

Analysis

Sun is supporting ONC+ as its native distributed enterprise foundation architecture, but will also support DCE for customers interested in DCE as an alternate architecture. ONC+ will be the foundation for Sun's strategic Enterprise Architecture, DOE (Distributed Objects Everywhere). ONC+ will be supported by all COSE vendors, as will DCE[41]. ONC has been submitted to X/Open, just as DCE is being submitted. However ONC+ was not selected by OSF for the distributed file service. Sun has since added transport independence (NFS TI-RPC) and plans to add Kerberos security that will bring it closer to DCE capabilities. Figure 4-1 illustrates the Sun ONC+ architecture compared to the OSF DCE model.

Table 4-1. Some ONC/DCE Architectural Differences

	Sun's ONC+	OSF's DCE
Threads Support *	RPC - No NFS - Yes but OS dependent	RPC- Yes OS independent DFS- Yes OS independent
Security	Some Kerberos in NFSv3, RPC w/Kerberos planned	6 levels of Security Kerberos-level security integrated with RPC
Shared File Services	Server-based Uses NIS+ Directory Services but requires more administration than DCE	Location transparent over the Enterprise - uses dynamic Directory Services
File Services Reliability & Fault Tolerance	Fair with NFSv3[42]	Excellent reliability and fault tolerance with DFS[43]

Note* Threads are critical to RPC efficiency in large scale implementations

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[41] Open Systems Today, March 29, 1993; A Move Toward Unity; Mitch Wagner, Graphic Text: "Interoperability - Each of the vendors will sell both the OSF's DCE and Sun's ONC+..."

[42] Open Systems Today, Oct. 25, 1993, Standards in Progress Column, The New NFS provides some big wins, but suffers from big drawbacks, too, Andy Feibus, "Two big problems, though: first NFSv3 does not specify and caching scheme....The second problem is potential failures in the server between when the WRITE requests are made and when the COMMIT request is made."

[43] ECS Note: Refer to Technical Overview of the OSF DCE architecture, DCE Distributed File Services

The DCE Distributed File System provides superior Location Transparency over NFS, especially over WANs. The DCE DFS unlike NFS, or even NFS+, is not server or domain centric.[44] The DCE DFS is also highly reliable and fault tolerant. Access is dynamic and highly transparent, restricted only by access permissions as administered by the DCE Security Service.

Sun has licensed the ONC+/NFS technology and it is currently the principal mechanism for shared file services between Unix and DOS/Windows/NetWare/Apple clients. DCE is a platform-independent technology and is capable of connectivity to PCs. It should be noted that outside of Sun and even within Sun platforms, it is often only NFS that is actually implemented.[45] And while widely supported as a file sharing mechanism, there are those that consider ONC+, despite its promised security features, a technology bound to an earlier computing environment.[46] [47] Transarc, who is providing DCE for Sun, has indicted that they expect a strong market on Sun. Chase-Manhattan is testing DCE capabilities on Sun workstations.[48]

Gradient Technologies' PC-DCE will provide the DCE equivalent technology for PC environments that will also include transport independence, supporting both connection-oriented and connectionless transport mechanism, including the Winsock (Windows Socket) API. PC-DCE will be capable of supporting full trusted-client support under 16-bit Windows 3.1 and subsequent versions of windows by building to the Win32 specification. PC-DCE provides support for DCE threads, time, naming, RPC and security services.

DCE, like Sun's ONC+, is intended and will be supported on most major platforms. IBM is targeting DCE as the strategic direction for OS/2, MVS[49] and AS/400[50], as well as AIX. DEC is supporting DCE under OSF/1 and VMS[51] platforms. Apple[52] has also indicated its support for DCE under the PowerOpen platform it is supporting with IBM.

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44 Open Information Systems, May 1993, Unix and PC interoperability: toward the utility era of computing, Stanley Dolberg; "While ONC dominates heterogeneous file and print management in the commercial market, DCE continues to hold significant promise as a scalable and robust basis for the development of distributed applications for heterogeneous environments."

45 Open Systems Today, April 27, 1992, DCE Slow Motion Act is Raising Questions, Paul Kapustra; "But although some users have adopted ONC, they rarely implement more than NFS."

46 PC Week, Aug. 23, 1993, NFS 3.0 Debuts, Mary Jo Foley, "The first upgrade to the distributed file service in six years, NFS 3.0....`SunSoft has made some incremental improvements -- mostly low-level techie stuff' said McGuckin [Gartner Group]. `Some of what they did was meant to head off the Open Software Foundation's DFS (Distributed File Systems)' "

47 Unix World, Feb. 1993, Tutorial [on the DCE RPC], Rik Farrow. "For those of you that have experimented with Sun's RPC, you will be immediately struck by the complexity of OSF's DCE - I certainly was. But then, times have changed. Although Sun's RPC was designed to operate in a heterogeneous environment, other concerns weren't as important. DCE, for example supports six different levels of security. DCE, also features another important component, Cell Directory Services, to handle connecting clients to servers transparently."

48 Communications Week, Oct. 11, 1993, Saroja Girishankar, DCE to get Object Programming", Goldman [CIO of Chase Manhattan Bank, New York] said Chase Manhattan has been testing DCE capabilities on workstations that run Sun Microsystems Inc's DCE-compliant SunOS operating system."

49 InfoWorld, June 7 1993, IBM readies distributed app development system. (DCE for OS/2, DCE for MVS/ESA and DCE for AIX/6000 application development), Jayne Wilson

50 InfoWorld, March 1 1993, IBM bundles AS/400s with network software, Ed Scannell, "In addition to the AS/400 bundles, IBM also announced its first developers' toolkit for the Open Software Foundation's DCE"

51 Digital News & Review, Feb. 1, 1993, Sarah E. Varney, DEC introduces DCE Toolkit for OpenVMS, "DEC will make available next month a Distributed Computing Environment (DCE) developer's toolkit."

52 DEC Professional, April 1993, The inevitability of DCE, Bradford Harrison, "In addition, Apple Computer has made public its plans to incorporate DCE into the Macintosh operating system Apple support for DCE."

Conclusion

In organizations that are not Sun-centric and have not targeted an Enterprise Architecture, such as that required by ECS and many other large organizations, NFS and to a lesser extent ONC+ will continue as the major file sharing architecture for a significant period. Over the long term, we expect ONC+ to become more and more a Sun specific implementation, which may be implemented where Sun workstations are the exclusive or predominant workstation. As occurred in an earlier OSF vs Sun situation, Sun supported the OpenLook GUI as the Sun standard but provided support for the OSF's Motif GUI for those that wished to implement it. Over time, other early supporters of OpenLook as a standard GUI, backed off to support OpenLook only as an alternative. Shortly before the March, 1993 COSE agreement, which included Sun, to support Motif as the standard X-Window GUI, there were numerous reports in the trade press, including Sun World[53], that many customers sites had over 50% Motif over Open Look implementations.[54] [55]

We expect organizations targeting an open and heterogeneous distributed enterprise architecture will select DCE over ONC+ because of its stronger services integration[56], much broader vendor options and portability. We also believe that because of these features, DCE is both better technically and a least risk solution over the long term.

Timeline:

3rdQ 94: We would expect to see DCE implemented in a significant majority of heterogeneous, distributed Enterprise architecture foundations and we would also expect to see DCE connectivity Software for NetWare, Apple, IBM AS/400s & Mainframes, PC platforms arriving.

3rdQ 95: Same as above and implementations with some portion of non-POSIX clients should be occurring.

4.1.1.2 NT Advanced Server

Microsoft is moving its flagship Windows desktop environment to a 32-bit operating system environment which is called Windows NT (New Technology). Microsoft is however raising its focus from the desktop to the distributed enterprise. NT Advanced Server is the Microsoft product

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[53] SunWorld, Feb. 1993, /Issues [Editorial Column], Dave Taylor; "Sun's Pivotal Year, Pivots not attained. Sun missed in a couple of important areas last year. Sun's insistence on staying with Open Look is highest on the list. The industry is busy building around Motif (half of Sun's customers use Motif), but Sun insists on the superiority of Open Look, to the significant detriment of its customers and the market-place."

[54] PC Week, Feb 8 1993, IXI ports Motif GUI to Solaris 2.1, Leach, Norvin, "Even at sites that primarily use Sun workstations, Motif is sometimes the preferred GUI, noted Rikki Kirzner, an analyst for Dataquest Inc., a San Jose, Calif., market-research firm. In a recent Dataquest survey of about 70 Sun installations, 20 preferred Open Look, while 14 used Motif."

[55] Digital News & Review, Nov 12 1992, More Sun users are choosing Motif over Open Look., Sarah Varney, "The survey revealed that 78 percent of Sun system sites currently use Motif on at least one machine. The X Business Group, a market research and consulting company located in Fremont, Calif., performed the survey. At these Sun sites, almost 30 percent of users employ Motif-based applications. And over the past year the penetration of Motif into the Sun base has more than doubled."

[56] Unix World, Feb. 1993, Tutorial [on DCE RPC], Rik Farrow, "DCE supports 6 levels of security. DCE also features another important component, Cell Directory Services, to handle connecting clients with servers transparently." ECS Note: The DCE RPC capability to use threads provides significant efficiencies over ONC+/NFS+ RPCs, which do not utilize threads.

that will be the focus of this distributed enterprise capability. As an enterprise foundation architecture, NT Advanced Server will compete with DCE. A risk analysis of this architecture follows.

Analysis

Microsoft has indicated support for DCE, at least at the RPC level. Microsoft will use a different programming interface than is used by DCE, i.e. the DCE RPC utilizes threads, and although NT also provides threads, it is different from that implemented by DCE and POSIX.[57] [58] Microsoft's approach allows some hardware independence, since NT will be available on non-Intel platforms. Microsoft is a rather new player in several areas of critical importance to the ECS Project: the Network and Server levels, supporting mission-critical, multi-platform,[59] [60] and scientific applications.

The NT Advanced Server feature set and capabilities are not considered as high as DCE features and capabilities by most observers.[61] Many reviews of NT cite support for OSF's DCE as one of its three or four best features[62]. Some consider that even with future Network products, such as Hermes, Microsoft will need to rely on DCE for a true cross-platform implementation.[63] [64]

Microsoft's participation in standards organizations and consortia is somewhat erratic, possibly due to the fact that it could dictate many standards on the Intel platform. Although Microsoft has

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[57] Unix World; Feb. 1993, Tutorial on DCE, Rik Farrow. p. 62, par. 4

[58] DEC Professional, April !993, Harrison Bradford, "Microsoft Windows NT RPC uses 79 of the 99 DCE v 1.0 APIs."

[59] Communications Week, Oct. 18, 1993, Just when you thought IBM was predictable, a surprise, Wayne Rash, "IBM has recognized, as more companies need to recognize, that customers need solutions that meet their needs. They don't need lip service to multivendor environments, as Microsoft delivers with NT Advanced Server."

[60] Communications Week, Oct. 18, 1993, Saroja Girishankar, NT Report Card: "Incomplete", "In addition, Microsoft has not been able to deliver a consistent or convincing argument about NT's role in Enterprise Networks. Microsoft officials declined to say how many copies of NT have shipped commercially. But evidence suggests that few copies of NT have been sold. Harriet Schabes, vice president at Citicorp technology said NT has a long way to go before it measures up to her organizations standards. ... Some users wonder whether Microsoft, with its heritage in PC software, understands the needs of enterprise users."

[61] InfoWorld, August 2, 1993, Microsoft's Client/Server Strategy, Karyl Scott, "According to Microsoft, the company intends to develop enterprise products, create a scalable platform for building client/server solutions. Currently, Microsoft, and its LAN Manager Product is lagging behind the rest of the industry. The competition not withstanding, Microsoft's forthcoming client/server product family is impressive, including Windows NT, NT Advanced Server, ... Critics say the company's lineup lacks both focus and depth, and many are skeptical of Microsoft's commitment to providing support."

[62] Byte, October 1992, Windows NT Up Close, John Udell, Graphic: "Key Features: .... DCE-compliant RPC..."
InfoWorld, Windows NT Supplement, May 24, 1993, "Where the rubber meets the road", Jim Canning, "One of the least heralded aspects of Windows NT is its compatibility with OSF's Distributed Computing Environment (DCE)....Engineering, scientific, and creative applications need all the performance they can get - why not borrow some from some idle nodes on the network....There are still a few issues around Microsoft's implementation of DCE that need cleaning up, but they aren't show stoppers."

[63] LAN Technology, March 1993, Scaling the Windows Skyline (Microsoft Corp.'s blueprint for network computing), Leo Spiegel and Susan Hetzel, "In addition, Microsoft's implementation of the Distributed Computing Environment (DCE)-compliant Remote Procedure Call (RPC) API will let users invoke processes and run applications on other Windows machines to distribute the power of Windows NT over the network. This valuable open standard links applications and devices and accommodates incompatibilities between them to pave way for truly heterogeneous, distributed processing."

[64] ComputerWorld, Oct. 18, 1993; Software distribution key to open systems; Jean Bozman, [Compares OSF's DME Software Distribution Service with Microsoft's Hermes software management utility for NT] "To reach open systems networks, Hermes will have to be made to work with the OSF's Distributed Computing Environment (DCE) architecture, analysts said. Nash [product manager for Windows NT] said that will be possible through Hermes planned compatibility with DCE's remote procedure calls."

provided a POSIX-compliant sub-system to NT, many observers regard Microsoft as minimally compliant to many "open" systems standards, especially regarding its lack of support for the X/Open's XPG criteria.[65] [66] [67] The Object Management Group (OMG), which has the support of all other major vendors for the Object Technology interoperability that will become increasingly important as a future IT, is currently trying to bring Microsoft back into active participation after a year's absence[68]. All OSF and COSE members actively work with this group to help define the object-interoperability that will be critical components of future operating systems and distributed environments.

Microsoft's Enterprise Management architecture, code-named Hermes, is not currently available and is targeted to managing Microsoft NT platforms only.[69] Microsoft has also had very significant delays in delivering many NT architectural components.[70] [71] Although Microsoft considers NT "open" because it has published many of the NT and Windows APIs, there are many observers who consider this "proprietary" and leading to "lock-in" to a single operating system vendor.[72]

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[65] Edge:Work-Group Computing Report, Oct. 1992, Unix: UNIX International champions UNIX System V in fight for high end desktop OS market.. "NT does not support XPG, and is minimally compliant with POSIX 1003.1. This significantly limits its compatibility with XPG- and POSIX-compliant applications."
Distributed Computing Monitor Jan. 1993 p. 20 Patricia Seybold Group 1993, Novell and USL: Open Netware is the way to beat Microsoft., J. Rymer and M. Goulde, "...Microsoft's minimally standards-compliant NT direction "

[67] Open Information Systems, Aug. 1992, Windows NT 3.1, Michael Gould, "POSIX Support May Not Appeal to Unix Developers. The POSIX support provided on Windows NT is limited exclusively to the 1003.1 standard. An X server from eXcursions will be made available for Windows NT from Digital and others. X applications do not have access to OLE or DDE, and Win32 applications cannot make POSIX calls. Features such as case-sensitive naming, additional time stamps, and hard links are supported for POSIX compatibility, and symbolic links and sparse files will also be supported in the future. Symbolic link support will be added when the POSIX specification is completed. While access to advanced Windows NT features from the POSIX subsystem is limited, it does include security and control of process threads. It is not possible for a POSIX application to use the graphical API, and screen control or access is limited.
Access to Win32 functionality is possible through the IPC mechanisms and named pipes, allowing POSIX applications to exchange data with Win32 applications. However, POSIX doesn't access the RPC mechanism or sockets, which makes it difficult to develop POSIX applications that can interoperate with other POSIX systems. Sockets has to be accessed through the Windows NT console interface. No support for SLIP or PPP is provided in NT's TCP/IP."

[68] ComputerWorld, Oct. 4, 1993, OMG seeks more user input for CORBA spec; Melinda-Carol Ballou; "Microsoft resumed attending OMG meetings several months ago after a year's hiatus .."

[69] ComputerWorld, Oct. 11, 1993, Hermes to manage Microsoft only, Elizabeth Horwitt, "Instead of embracing foreign systems, Microsoft will leave it up to its partners, 23 of which were announced at a briefing here [Dallas - NetWorld] last week, to integrate Hermes with their own management of LANs, internetworking devices and other vendors clients and Network Operating Systems, Microsoft spokesmen said."

[70] ComputerWorld, Aug. 9, 1993, NT users sound off, Christopher Lindquist; "Long, long ago, NT was going to be a 32-bit operating system that everyone could use. ....[Quoting from bulletin board comments:] `It seems the faithful Windows users who want 32-bit processing are forever *waiting* for *something* from Microsoft!'"

[71] InfoWorld, Aug. 2, 1993, Microsoft's Client/Server Strategy, Karyl Scott, "Yet efforts directed at the enterprise market to date have been less than successful. LAN manager has just 5 percent of the LAN market, Microsoft SQL Server lags behind its competitors in the client/server database market and Windows NT has been delayed and refocused numerous times. Too many premature product disclosures and shifting strategies have left IS managers wondering whether Microsoft really has a strategy for large, heterogenous computing environments." ...But Windows NT is hopelessly late, and its server component, NT Advanced Server, initially tagged to compete against Novell Netware, now seems positioned as a high-performance application processing platform for running systems such as distributed databases. ... `I don't believe Microsoft has a true client/server strategy,' says Steve Mallion, LAN administrator with the Bank of Canada. `And if they do have one, it's certainly not suited to large enterprises such as ours.'"

[72] LAN Technology, March 1993, Scaling the Windows Skyline (Microsoft Corp.'s blueprint for Network Computing) Leo Spiegel/Susan Hetzel, "Following the complete Microsoft strategy poses a greater risk because companies will be putting all their eggs in one basket. on both terminal and business fronts. For most companies, the opportunity to deflect investment risk in several directions is a much safer choice in the long run."

Microsoft's position in the industry and broad implementation levels cannot be ignored over the long term. In our technology timeline, included in this report, we will continue to track this architecture as it matures. We will also track this vendor's commitment and implementation of POSIX and OSI standards in its strategic direction, as well as its cooperation with vendor-independent standards groups such as X/Open and the OMG that could possibly make NT Advanced Server attractive as a future migration path.

Microsoft has announced an aggressive pricing strategy and may be successful in gaining market share, but we believe this will be in PC-centric installations.

Conclusion

Although an object-oriented version of NT, code named Cairo, has been frequently mentioned by Microsoft, the company estimates that this will not be available before mid-95, which may be very optimistic considering the two year slippage on the original NT. The current implementation of Microsoft Windows NT is very new on all levels: new OS, new network services, and new applications from a vendor whose main success, albeit very impressive, has been at the desktop level. Although Microsoft is branching out to non-Intel platforms, these implementations are also on a new operating system. The implementation is currently too new on all levels and too immature to be an acceptable risk for the short term or the long term.

Microsoft has participated erratically in standards organizations and its long-term commitment to standards, such those provided by IEEE, ISO and X/Open[73], which is considered a major risk mitigation factor, has not been demonstrated. Both the short and long term risks are very high and NT was eliminated from consideration because of these very high risk factors.

Table 4-2 summarizes Microsoft support for major standards risk mitigation factors.

[73] Open Systems Today, March 1992, Unix gets `open' edge over NT; Mitch Wagner; " Though Microsoft said it will support POSIX, ...POSIX defines only the shell and calls at this point, with security, distributed-systems and other standards forthcoming. By comparison, X/Open, through its XPG process, defines standards for graphics, device I/O, languages, and more. Microsoft said third-party companies are working for XPG compliance, but Microsoft has no plans to bring its own software into XPG compliance."

Table 4-2. NT Support for Risk-Mitigating Standards

	POSIX 1 (1988)	POSIX 1 (1990)	X/Open XPG (Portability Guide)	Object Mgt Group's CORBA	Plans Aligned with Future POSIX direction
OSF DCE	Yes	Yes	Yes	Yes	Yes
Novell NetWare	No	No	Yes (?)[74]	Yes	No
Microsoft NT	Yes[75]	No[76]	No[77]	No[78]	No[79]
Sun ONC+	Yes	Yes	Yes	Yes	Yes

Timeline:

2ndQ 94: We would not expect to see the NT Advanced Server implemented as a foundation Enterprise Architecture for organizations with truly heterogeneous installations, including large numbers of heterogeneous POSIX devices.

3rdQ 94: Same as above.

3rdQ 95: Same as above.

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[74] ECS Note: Novell has been working with the COSE group for USL, but has also proposed NetWare standards for inclusion. Although support from the USL side is very strong for all open systems standards, NetWare will remain a proprietary solution, although widely implemented.

[75] UnixWorld, Feb. 1993, Understanding Windows NT, Rik Farow, "The Posix subsystems will have a fork() system call, along with all the system calls required by Posix 1003.1, the specification approved in 1988. But Unix and Posix have moved on. X/Open Company Ltd.'s Portability Guide Issue 3 (XPG) or the new XPG4, provide a better definition of open systems than the older Posix standard, but Microsoft has not announced any plans to be XPG-compliant. In fact, Windows, NT programmers will have to learn to be Win32-compliant for the graphics, I/O, and threads interfaces, etc. Microsoft is setting its own standards."

[76] UNIX Review, March 1993, Emerging Standards, Hal Jesperson; "X/Open's Portability Guide (XPG) is used worldwide as an open systems procurement and development tool. With the latest release, XPG4, the specification has expanded into the areas of interoperability and communications. This comprehensive environment covers all the standards, above the hardware level, that are needed to support open systems. XPG defines detailed specifications and interfaces for communicating within this framework. Its policy is to use de jure standards where they exist and to adopt widely supported de facto standards in other cases. X/Open works closely with the various standards bodies and with other consortia to incorporate such standards and technology components. XPG3 is fully aligned with the IEEE UNIX Review, March 1993, Emerging Standards, Hal Jesperson; "XPG3 is fully aligned with the IEEE standard 1003.1-1988 (POSIX), while XPG4 is aligned with POSIX 1003-1-1990."

[77] Open Information Systems, August 1992, Windows NT 3.1, Michael Goulde, "Why Bother with POSIX? It is not Microsoft's intention to provide a full XPG/3-compliant system with Windows NT nor to encourage any serious development using the POSIX interface. The company makes it clear that POSIX 1003.1 is there because it has to be there in order to qualify for federal government bids."

[78] ComputerWorld, Oct. 1993, OMG seeks more user input for CORBA spec, Melinda-Carol Ballou, "Corporate sites developing distributed applications require standards that are common across vendor offerings, and one of the key emerging standards is the Common Object Request Broker Architecture (CORBA) from OMG, a consortium of vendors and end-users with headquarters in Framingham Mass. Backing CORBA - While Microsoft has pulled out the stops for Object Linking and Embedding (OLE 2.0) and Cairo, its strategy for distributed computing, other systems vendors have banded behind the OMG's Corba as a standard for enabling objects to communicate with one another.""

[78] UnixWorld, Feb. 1993, Understanding Windows NT, Rik Farow
UNIX Review, March 1993, Emerging Standards, Hal Jesperson

[79] ECS Note: Microsoft plans to integrate NT with a Distributed Network capability code-named Hermes.. Unlike the DCE, DME, and ONC future directions, which are already largely based on the Posix drafts, and will continue to evolve with the specifications of POSIX 1003.7 (Systems Administration), Microsoft's Hermes will take it's own direction for software distribution, print services, etc.

4.1.1.3 Novell's NetWare

Novell's NetWare is a widely implemented Network Operating System (NOS). NetWare provides operating system and network services. Novell has recently upgraded NetWare (4.0) to provide Enterprise capabilities. Novell has announced an ambitious object-oriented application development environment. It has also recently acquired Unix Systems Laboratories (USL) and its standard Unix (SVR4) product, which is called UnixWare. While Novell is supporting an open systems strategy, which includes DCE for the UnixWare product, the NetWare NOS will remain proprietary. Novell has provided exceptional connectivity to diverse platform

Analysis

Novell has indicated support for DCE for UnixWare and NetWare. While DCE will be supported under UnixWare as a core technology, it will also be supported as a connectivity option for DCE implementations rather than a core capability under NetWare.[80] Novell is evolving its SAS (System Application Services), it is also providing API services for a wide variety of operating system clients, which is the high-level framework or layer approach used in DCE[81]. The most important of these will try to provide an Enterprise Architecture by building the DME-like portions with a CORBA-compliant Distributed Object Management System (DOMS) from HyperDesk[82], one of the founding members of OMG. This technology will be embedded[83] and shipped with the NetWare product[84]. Continuing this object-oriented strategy, Novell has also purchased equity stakes in several other companies and announced partnerships with still others[85]. Although this high-level architecture is a very attractive, open-systems implementation, the underlying NetWare NOS foundation is highly proprietary. The age of the NetWare Operating System architecture and its inability to evolve with new architectures is demonstrated by the fact that it cannot support On-Line Transaction Processing (OLTP or TP Monitors) nor Symmetric

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[80]Distributed Computing Monitor, Jan. 1993, Novell and USL: Open Netware is the way to beat Microsoft, J. Rymer and M. Goulde, "However, USL has already committed to DCE .... Novell resolved this conflict by committing to support DCE as an interoperability mechanism between NetWare and the rest of the world."

[81] Distributed Computing Monitor, April 1993, Common APIs key to Novell's new developer strategy. "Novell's approach stands in stark contrast to that of Microsoft, which is seeking to provide a single, uniform operating environment for all needs."

[82] Open Systems Today, Feb. 15, 1993, Open Systems Advisor column, Nina Lytton, DOMS: Novell's Ticket to outdo Microsoft and Push Interoperability; "At NetWorld, Novell announced it had acquired a 20% stake in HyperDesk and is porting the HyperDesk Distributed Object Management System (DOMS) to Netware. Novell is thereby simultaneously erecting a hurdle in Microsoft's path and disciplining the Unix community to interoperability among the various implementations of the Object Management Group's Common Object Request Broker Architecture (CORBA). .....DOMS, together with C++ are the first steps toward a common API for Netware and UnixWare."

[83]Open Systems Today, Building a Mainframe-like Net Infrastructure, Vendors Plan Application Services for Mixed Networks, Paul Kapustka, [Graphic text] "By embedding Hyperdesk Distributed Object Management System in NetWare, Novell plans to make Unix and other applications available to NetWare clients.

[84]Distributed Computing Monitor, Feb 1993, DOC: [Distributed Object Computing] the next stage. Introduction to three reports on distributed object computing's emergence for corporate applications development, John Rymer, "We begin with an analysis of Novell's decision to license HyperDesk's Distributed Object Management System (DOMS) for versions of Netware starting in the autumn of 1993. In short order, a distributed object management platform will be available on potentially many thousands of customer sights. Distributed object computing has arrived at the corporate mainstream."

[85]Distributed Computing Monitor, April 1993, Common APIs key to Novell's new developer strategy, J. Rymer, "A common thread in these relationships is Novell's desire to support a rich, object-oriented interface to its networking platform. ...For HyperDesk, this means that Novell must create a set of class libraries in the Interface Definition Language (IDL) provided with HyperDesk for that purpose. IDL is part of the Object Management Group's Common Object Request Broker Architecture (CORBA) standard

Multiprocessing (SMP) directly on NetWare Servers. This effects the architecture's scalability as well as its capability to evolve with even newer technologies. The Third Party Products Study outlines in more detail the Enterprise functionality that can be obtained from the new generation of distributed OLTP or TP monitors.[86] DCE supports much greater extensibility as well as vendor/platform support and will support a more open and effective high-level Enterprise Architecture. The older NetWare NOS cannot support microkernel architectures, which are able to provide multiple operating systems as sub-systems or personalities and are becoming increasingly available. Microkernel architectures are available for NT and Unix, and planned for Taligent (IBM/Apple). Microkernels also offer possibilities for "loosely coupled" massively parallel systems.[87] We believe that Novell's support of the current NetWare architecture is largely based on competitive strategies unique to Novell. [88] [89]

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[86] PC Week, Aug. 23, 1993, Novell ponders SMP for Netware; OLTP would drive enterprise strategy; Eric Smalley, "Novell, Inc. is struggling with the possibility of adding Enterprise transaction processing capacity to Netware but maybe unable to do so due to limitations in the operating system. .....Paul Bandrowski, director of advanced technology for Sara Lee Corp. in Chicago. `That disappoints me,' he said ;`There's no scalability.'"

[87] Unix World, November 1993, Rik Farrow, Microkernels, p. 64

[88] Distributed Computing Monitor, April 1993, Common APIs key to Novell's new developer strategy; J. Rymer, "Netware 4.0 competes directly with DCE and, as might have been expected, is Novell's favored approach to supporting distributed computing."

[89] Open Systems Today, Oct. 11, 1993, The User Odyssey, Sally Atkins, " Just as some customers were ready for Unix while the sales force continued to push VMS, so, too, are many users today ready for Novell's Unix and IP products and awaiting concrete answers on whether and when DCE products will come along. Novell needs to let the long-term needs of its customers drive its own plans - rather than pushing more proprietary than open for the sake of today's revenues alone."

Novell's Architecture compared with other evaluated solutions is compared in Table 4-3 below.

Table 4-3. Comparison of Enterprise Capabilities and Market Support

	NetWare	NT/Hermes	Sun's ONC+	DCE/DME
Platform Independent	No	Yes	Yes [90]	Yes
Operating System Independent	No, however UnixWare provides limited Unix support	No	Yes	Yes
Heterogeneous Distributed Communications	Yes	No	Yes (ONC+)	Yes
Inter-application Communications over Distributed Network	Yes** (CORBA)	No (OLE 2 cannot fully support)[91]	Yes, but threads not utilized in RPC	Yes - RPC with DFS & CDS/GDS
Support for CORBA	Yes**	No	Yes**	Yes**
Level of Directory Services	Excellent[92]: Large Enterprises	Good: Small Enterprises[93] **	Very Good: Moderate Enterprises[94]	Excellent: Very Large Enterprises
OLTP Support	No [95]	Yes [96]	Yes	Yes***
SMP (Symmetric Multi-processing)	No [97]	Yes	Yes	Yes
Object - Oriented Dev.	Yes **	Yes **	Yes	Yes **
Preemptive Multitasking	No [98]	Yes ** [99]	Yes	Yes * & with RPC
Microkernels	No	Yes	No	Yes *
Market Support	Yes	Some in PC-centric LANs	NFS only - Yes ONC+	

* On most supported Operating Systems ** Planned ***Via third-party add-on

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[90] ECS Note: ONC+ is currently strongly tied to the SPARC and Intel platforms.

[91] ComputerWorld, Sept. 27, 1993, Desktop Application Development, Michael Vizard and Ed Scannell, "Another problems some developers see is that OLE 2.0 cannot support the transfer of OLE files over networks. Microsoft officials have acknowledged that users will not be able to move or delete OLE files over Networks until the company ships Cairo [next generation NT] sometime in 1995."

[92] InfoWorld Supplement on Windows NT, May 24, 1993, "NetWare is ahead of the pack for enterprise management. Advanced Server does not offer the hierarchical depth of Netware's NDS" [DCE not included in comparison - comparisons between Netware Directory Services and DCE compare them favorably - NetWare 4.0 has implemented DS after the OSF model.]

[93] InfoWorld, Windows NT Supplement, May 24, 1993, Battle for Technical Superiority, "Windows NT Advanced Server does not offer the hierarchical depth of NetWare's NDS. IBM's LAN Server 3.0 includes domain-based management suitable for a small enterprise."

[94] ECS Note: RPC's without integrated threads capabilities are not efficient enough for large scale implementations.

[95] InfoWorld Supplement on Windows NT, May 24, 1993, The battle for technical superiority; "Novell Netware 4.0: Still leading in connectivity. .. The fly in the ointment is a continued lack of preemptive multitasking and support for symmetric multiprocessing (SMP). This should keep NetWare out of the market for real-time application servers and on-line transaction processing [OLTP]."

[96] ECS Note: Sequent & DEC will provide in their NT implementations. Only DEC plans support for a standard /XA OLTP monitor and DEC has announced its intent to port DCE to NT in its implementations.

[97] InfoWorld Supplement on Windows NT, May 24, 1993

[98] InfoWorld Supplement on Windows NT, May 24, 1993

[99] ComputerWorld, Aug. 9, 1993, NT users sound off ; Christopher Lindquist; [Reporting Bulletin Board comments] `According to reliable sources, it appears that Chicago [next generation NT] applications, while multitasked preemptively in relation to one another, will feature cooperative multitasking internally within the individual applications. That's right -- no true multithreading, just some sort of cooperative kludge.'"

The vendor's current presence in the PC LAN marketplace, with estimates of up to 70% [100] [101], as well as the vendor's recent acquisition of USL and its participation in the COSE consortium would indicate the need to track Novell's solution for impact on the ECS Risk Mitigation Plan.

Conclusion

Although working with the COSE[102] group and complying with many of X/Open's XPG[103] guidelines for its UnixWare product, unlike competitor Microsoft, Novell intends to use enhanced NetWare as the foundation architecture for its high-level Enterprise Architecture. We consider that the underlying Novell NetWare architecture is largely proprietary and not as capable or extensible as newer architectures, such as NT or DCE. We consider that this will make Novell's NetWare Enterprise architecture a short- and long-term risk. We will track Novell as an Enterprise Architecture, particularly as regards continued integration with its USL subsidiary's, work with COSE and X/Open and its integration strategy regarding DCE. [104] [105]

Timeline:

3rdQ 94: We would not expect to see the Novell Enterprise Architecture implemented as a foundation Enterprise Architecture for organizations outside of existing Novell shops. We would expect a number of former Novell sites to begin to migrate to DCE.

3rdQ 95: Same as above

4.1.2 Other Risk Factors Considered

In addition to competing architectures there are risk factors to be considered in the selection of any architecture. The following section reviews three additional risk factors that have been considered in selecting OSF DCE:

- Functional levels provided by standards/API implementation
- Dependence on OSF for solution stability
- Slow acceptance and implementation of DCE

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[100] InfoWorld, August 16, 1993; Letter to the Editor,. Bill Gates -"...In networking, we face Novell, which already owns more than 70% of the market...."

[101] LAN Magazine, April 1993, Directory Assistance, Sara Radicati/Nina Burns; "Novell dominates this market segment because of its large installed base--nearly 70 percent of the PC LAN market."

[102] Software Magazine, July 1993, Middleware needed to plug c/s holes, Janet Butler, "Last March, six unlikely bedfellows banded together against the impending threat of the Windows NT release from Microsoft Corp., Redmond, Wash. Hewlett-Packard, Cupertino, Calif.; IBM; Sun Microsystems, Inc., Mountain View, Calif.; The Santa Cruz Operation (SCO), Santa Cruz, Calif.; Univel, San Jose, Calif.; and Unix System Laboratories met to form a deliberately unnamed common open software environment (Cose) across their respective Unix platforms"

[103] Distributed Computing Monitor, Jan. 1993, Novell and USL: Open Netware is the way to beat Microsoft, J. Rymer and M. Goulde

[104] Open Systems Today, Oct. 11, 1993, Growing Momentum for DCE Products; Paul Kapustra, Article reported Novell held meeting at San Francisco Interop with users who had very high interest in DCE.

[105] Distributed Computing Monitor, April 1993, Common APIs key to Novell's new developer strategy, J. Rymer; "Our biggest doubts about Novell's strategy concerns DCE. ... Many of the customers who are planning such applications have already decided to make DCE a centerpiece of their architectures."

4.1.2.1 Functional Levels Provided by an API/Standards-based Implementation

There has been some criticism of "open systems" implementations not being as fully functional as more proprietary systems. Some critics maintain that the standards agreed upon by consortium committees are often the least common denominator. These critics maintain that these "standards by committee" are not robust enough to support the diverse functionality required by many organizations. A risk assessment of the functional levels that can be supported by the standards-based DCE distributed enterprise architecture follows.

Analysis

While we believe that the use of standards and APIs is a critical component in the overall risk mitigation of DCE as an architectural component, it may not be able, nor is it intended, to provide all the functionality that ECS requires in a particular area. DCE has been identified as a foundation architecture. This type of architecture is attractive not only as a risk mitigating architecture for users and organizations, but as an attractive architecture for third party developers. The DCE open architecture will allow even very small firms to leverage their investment over a significant number of DCE-supported platforms, concentrating their creativity and resources in providing application functionality rather than in extensive porting exercises.

As is discussed in the “Third Party DCE Products Study,” we are evaluating products from third party vendors. ECS will review a variety of products that are currently available on several platforms to supplement and enhance the functionality we believe is critical to the effectiveness of the ECS Project. While we will make no selection that would jeopardize the overall risk mitigation capabilities of the DCE foundation architecture, we intend to select products that will provide robust and full-featured capabilities for the project. We may be selecting products that will enhance DCE features in areas where additional functionality is considered essential for the effectiveness of the ECS Project.

While we fully expect DCE to advance as an architecture and provide increasing services and capabilities, we do not expect, and OSF did not intend, to have DCE provide all features and capabilities that any single organization may consider critical. The APIs endorsed by DCE are to provide a more plug and play environment for third party vendors enabling them to provide the enhanced features and capabilities that many organizations would find attractive or essential.

Although risk mitigation is definitely DCE's strongest feature because of the extent of platform support, the next most important feature of DCE is its potential for plug and play applications to add value and provide extensibility and features. Again, it should be noted that with one exception, all of the third party applications we are reviewing are not from the major operating system or network vendors. The capabilities of these applications are nevertheless Enterprise-class.

We believe, because of hierarchical nature of earlier systems, evolution to new technologies was very, very difficult. The industry has learned from this experience. DCE's and DME's Services are modularized, utilizing APIs, so that one "service" can be upgraded with new technologies with minimal to moderate effect on other services.

Conclusion

We believe the use of standards and APIs is a highly effective method of risk mitigation, especially when used to mitigate the risk associated with the major architectural components, such as DCE. DCE was also selected because of its capability to support advanced technologies and encourage innovative development. Several applications that can offer significant additional features and functionality over current DCE capabilities have already been identified for consideration and are outlined in the "Third Party Products Study." ECS will have full functionality in critical areas while mitigating the highest risk factors for a major architectural component.

Timeline

2ndQ 94: We would expect continued availability and functionality of DCE-compliant applications to increase, providing a number of applications to enhance basic DCE services in areas where additional functionality is needed.

3rdQ 94: Same as above

3rdQ 95: Same as above

4.1.2.2 Dependence on OSF for Solution Stability

Although OSF DCE is completely vendor and platform independent and will not pose a risk in that regard, we must consider, as a risk, the stability of DCE specifications and support if OSF can not or does not continue with the DCE and DME work.

Analysis

There have been some trade journal reports of restructuring in OSF. This has lead to some questions concerning the ability of OSF standards to be continued if supporting vendors cannot continue support for financial reasons. As indicated in the OSF overview, when an OSF specification is finalized, it is turned over to X/Open for review. X/Open may return the specification for adjustment any number of times, often to assure vendor neutrality and resolve potential conflicts with other X/Open standards. When finally accepted, X/Open publishes the specification and announces the testing suite for branding. DCE is currently being submitted to X/Open and the standard specification and branding will be supported by X/Open, not the OSF[106]. The COSE consortium has used X/Open in the same way. X/Open will maintain Motif/X-Window specifications from OSF and brand products for compliance to these standards. It also has been announced that X/Open will maintain Unix trademark certification of 1,170 APIs that comprise the baseline Unix from USL.[107] If OSF eventually disbands, X/Open will maintain the consistency of the DCE standards through the branding process. If a major change is needed, it is almost certain that a vendor consortium will be formed to work on the specification and then submit it to X/Open. The standards process is most successful when maintained and branded by a

[106] DEC Professional, April 1993, The inevitability of DCE, Bradford T. Harrison; "DCE is to become part of the X/Open Portability Guide specification, along with POSIX and other popular application programming interfaces."
[107] ComputerWorld, Oct. 18, 1993, Novell transfers Unix trademark to X/Open.

vendor-neutral organization, such as X/Open, that also supports interoperability verification. X/Open's highly regarded XPG (X/Open Portability Guide) and other "profiles" are used extensively by large and small organizations as well as the Federal Government in risk mitigation plans.[108] [109]

Conclusion

OSF has been moving the specifications for DCE (and DME) to the widely accepted X/Open group. These will be included and integrated with X/Open's other standards [110] [111]. X/Open will also oversee conformance testing for OSF technologies. The continuity and stability of DCE will be maintained outside of OSF.

Timeline: (N/A)

4.1.6 Slow Acceptance and Implementation of DCE

High levels of industry acceptance and implementation of DCE will decrease risk for organizations implementing DCE. Lower levels of industry acceptance and implementations will indicate a greater potential risk. The risks due to levels of industry acceptance and implementation of DCE and the appropriate time frames to consider this risk is discussed below.

Analysis

DCE, as a foundation Enterprise Architecture, requires significant organizational commitment. The real benefit of DCE is in large scale Enterprise-wide implementation, which must be considered carefully. This is often a slow process and some organizations are only becoming aware of DCE capabilities[112]. We believe acceptance will be high in organizations considering an

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[108]Open Information Systems, Jan. 1993, X/Open in the 1990's; making open systems safe for users?, Stanley Dolberg, "X/Open is the single most effective point of leverage users have for influencing the form and speed of open system evolution." ..."NASA issued RFP early in 1992 ...required compliance with two specific standards: POSIX and [X/Open's] XPG3."

[109] LAN Computing, Oct. 1992, XPG4 spec released (X/Open Portability Guide from X/Open Company, Evan Birkhead, "X/Open has garnered impressive support from vendors, standards consortia, Fortune 500 companies and government agencies. Today, inclusion in the XPG profile is considered recognition that a standard has achieved industrywide status."
UNIX Review, March 1993, Emerging Standards, Hal Jesperson; "X/Open's Portability Guide (XPG) is used worldwide as an open systems procurement and development tool. With the latest release, XPG4, the specification has expanded into the areas of interoperability and communications. This comprehensive environment covers all the standards, above the hardware level, that are needed to support open systems. XPG defines detailed specifications and interfaces for communicating within this framework. Its policy is to use de jure standards where they exist and to adopt widely supported de facto standards in other cases. X/Open works closely with the various standards bodies and with other consortia to incorporate such standards and technology components. XPG3 is fully aligned with the IEEE standard 1003.1-1988 (POSIX), while XPG4 is aligned with POSIX 1003-1-1990.
X/Open has quickly become the most widely used, independent, open-systems procurement specification by governments and commercial organizations around the world."

[110]Digital News & Review, Sept. 1992, X/Open Moves to Embrace DCE, Ted Bowen, "Open systems certification body, X/Open, will begin testing and verification of the OSF DCE to allow it to be added to its list of industry-standard technologies."

[111]The Token Perspectives Newsletter, Oct. 1992, OSF's DCE to be incorporated into X/Open's CAE, "X/Open and the Open Software Foundation have announced a joint-initiative to integrate the OSF's Distributed Computing Environment specifications into X/Open's Common Applications Environment (CAE). [XPG is a subset of CAE]."

[112]DEC Professional, May 1993, The Layers of Network Security, Bradford Harrison, "Approximately 80% of mainframe sites know little or nothing about OSF and its products, says Frank Dodge, President of the Dodge Company. His firm helps

Enterprise Architecture, but Enterprise-wide implementation will be slow because of the commitment involved. Many organizations will initiate substantial testing before committing to a new Enterprise Architecture. Some less than leading edge organizations may even wait until DCE is implemented by almost everyone else before embarking on their own implementation.

We expect DCE to be implemented at approximately the same rate as other major architectural changes - possibly very slowly. However, as organizations do make an Enterprise commitment to client/server and distributed architectures, we expect it to be the widely accepted DCE [113] [114] which will support the most full-featured and advanced Enterprise foundation architecture as well as the broadest range of operating system, network, and application choices.

Conclusion

Slow acceptance and implementations in themselves will not be considered indications of significant risk, unless a significant alternate Enterprise Architecture such as ONC or NT is being implemented.

Timeline:

3rdQ 94: We would expect to see significant activity in small scale DCE "prototypes". We expect to see the majority heterogeneous Enterprise implementations supporting DCE, outside of Sun-centric and PC centric environments.

3rdQ 94: Obtain and examine market share data to determine acceptance of DCE within the end-user community.

3rdQ 95: We would expect to see implementations beginning in many large Enterprises.

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companies migrate from mainframe to client-server platforms. The 20% who understand OSF's offerings are interested in DCE, he says. ... Those that know believe DCE will be the standard."

[113] Communications Week, Sept. 20, 1993; Jeffrey Schwartz, Retailer Buys into X.400; "`It is apparent to us that X.500 will be a strong and prevalent directory technology. It is built into the DCE. We view DCE as a logical step that we'll be taking soon and we felt that we'll be taking soon'...Schmidt said".[Vice President of information technology and communications at Wal-Mart]

[114] PC Week, May 24, 1993, Norvin Leach, DEC preps DCE for OSF/1 Unix; "DCE is well on its way to becoming the Unix industry's standard for distributed computing, said Rikki Kirzner, senior industry analyst with Dataquest Inc., a market researcher in San Jose, Calif. `Based on the amount of interest and the amount of R&D being thrown at it, it looks like it will become the de factor standard,' Kirzner said `I don't know of a single vendor who's not planning to provide a version of it'."

5. Conclusions

The Distributed Computing Environment from the Open Software Foundation meets all basic and additional desired criteria we have set forth for an open and evolving distributed enterprise architecture:

✔	DCE is an integrated computing environment consisting of components whose functions and interfaces comply with widely implemented, vendor-neutral standards, including very high levels of platform and operating system independence.
✔	DCE provides interoperability, applications portability and scalability.
✔	DCE provides of a transparent as well as uniform set of highly reliable and secure services, across a broad variety of heterogenous devices and platforms, anywhere in the enterprise network.
✔	DCE is also capable of evolving as new technologies emerge with minimal to moderate impact. DCE's modular Services components were designed to minimize this impact on developers.
✔	DCE supports a very strong risk mitigation strategy supporting very strong "open" systems standards such as POSIX, XPG and OSI. DCE has very broad vendor support and many already consider DCE as a de facto standard.

The following summarizes the DCE risk mitigation analysis that has been conducted in this study:

Short-Term Risks: Very Low

- Basic DCE Services products are available and shipping from a number of industry sources. [115]
- Wide industry support that will minimize risk very substantially. [116] [117]
- Strong standards base will mitigate risk.
- DCE is to be submitted for inclusion in X/Open's XPG (X/Open Portability Guide), which is one of the most highly regarded risk-mitigation guides, by vendors, corporations and the federal government. Although acceptance is not guaranteed, it is considered very likely, especially where it is OSF's intent to have the DCE specification maintained by X/Open,

[115] ECS Note: Refer to Third Party Products Study

[116] LAN Magazine, May 1993, Having an Open Mind Interoperability Supplement, Cheryl Krivda, "...But all of our major accounts are evaluating DCE, planning for DCE, depending in DCE, or praying for DCE," notes Grover Righter, director of product management for the Santa Cruz Operation (SCO, Santa Cruz, CA)."

[117] Open Systems Today, Oct. 11, 1993; Growing Momentum for DCE Products; Paul Kapustra, Article commented that vendor (Atrium Technologies) noted the marked increased level of interest in DCE since last Uniforum.

who will also administer the Motif (OSF)/X-Windows [118] Specifications under the COSE agreement.

- Development and DBMS toolkits are available - new and innovative products are beginning to ship and be announced that will add substantial functionality to the DCE development environment. This topic will be discussed in the Third Party Products Study. DCE's enhanced capability to support high levels of Object-Oriented technology will attract innovative developers.
- The DCE foundation architecture is capable of supporting and evolving with the increasing Object Technology expected in future Operating Systems and Networks [119] [120], whether this technology continues to be provided as a framework or middleware between the Operating System and Network or as technologies integrated directly into the Operating System, standard GUI or even embedded in the Network architecture itself. This importance of this topic is discussed in detail in a future DME study.

Long-Term Risks: Very Low

- DCE will serve as the foundation component for the ECS Enterprise Architecture. This architecture is capable of evolving as expected Object-oriented and other advanced technologies emerge, especially those related to images and imaging, minimizing risks that the ECS Project will "out-grow" DCE.[121]
- DCE will serve as an optimal foundation for a DME-like architecture - whether DME or an alternative. DCE itself is a risk mitigating architecture for the integrated Distributed Enterprise System and Network Management architecture. If DME is delayed or experiences significant technical problems, which we believe is a moderate to low risk, DCE's naming[122], file and security services[123] will provide a more solid foundation for alternative architectures. This topic will be addressed in more detail in a DME study.

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[118] Distributed Computing Monitor, April 1993, "In addition to the desktop environment specification, OSF will submit the Motif specification for X/Open's consideration"

[119] Distributed Computing Monitor, June 1993, The Quest for Management Application Integration, "Used in conjunction with the common naming and security services of the OSF Distributed Computing Environment, CORBA could be the basis for a powerful solution, says Gil [Technology Planner from Charles Schwab & Co., representing the views of a large Network user]"

[120] Distributed Computing Monitor, August 1992, Distributed Object Computing: the Merger of Distributed Computing and Object-Orientation into a New Architecture, John Rymer, Article discusses "why distributed computing and object-oriented programming are both complementary and symbiotic." in that each extends the capabilities of the other.

[121] Distributed Computing Monitor, Feb. 1993, John Rymer, "The advent of the Open Software Foundation's (OSF) Distributed Computing Environment (DCE) focused the industry on establishing stable, integrated platforms of networking services. Stability in naming, security, file services, and remote execution services is vital to the establishment of interobject messaging, remote invocation, and related systems."

[122] LAN Magazine, Sept. 1993, Directory Assistance, Sara Radicati and Nina Burns, "OSF DCE. Early on the OSF recognized the key role directory services play in distributed computing .... The work also resulted in an architecture that serves as a model for much of the industry's new directory-services integration work. ...A large number of vendors, not associated with the OSF are adopting a similar architectural model for their non-X.500 directory service implementation and could co-exist and interoperate with X.500 directory services."

[123] ComputerWorld, Sept. 20, 1993; DCE: Ready ... set.... go?, Jean S. Bozman; "...early users said they have high hopes for the nascent technology. They expect client/server systems to benefit from DCE, which ensures consistent file handling and security throughout an enterprise network. ...Early adopters come from Universities, science laboratories and government, but some large companies such as Citicorp and the Boeing Co. also plan to use DCE in next-generation client/server systems."

5.1 Conclusion Summary

DCE will be supported by all major vendors. DCE specifications for Release 1.0.2 have been finalized and products are shipping from a large number of vendors supporting multiple platforms. While there are one or two major vendors, such as Sun and Novell, that will not make DCE a core technology, this decision has much more to do with the vendor's competing products than actual DCE capabilities. Even these vendors will support DCE as an alternative technology because of DCE acceptance as a de facto standard. The near universal support, exceptional technical capabilities of DCE, and the very high level of de jure and de facto standards in DCE have led to the conclusion that DCE will provide both a superior technical and least risk solution as the foundation Distributed Enterprise Architecture for ECS. Other significant alternatives are either too immature (NT Advanced Server), too proprietary (Novell's NetWare), or have not generated the broad general support of the industry as a platform-independent Enterprise Architecture for the long term (ONC+). We will continue to track these alternatives to continually verify the ECS risk mitigation strategy, in accordance with the timeline shown in Appendix A.

Appendix A. Risk Mitigation Timeline

4thQ 93	Announced Release of DCE Version 1.0.3
2ndQ 94	Track progress of Microsoft NT across multiple platforms/OS's
2ndQ 94	Re-survey DCE products. Expect increased availability and functionality of DCE-compliant applications. Also expect DFS release by most vendors
3rdQ 94	Review vendor products for update to lastest version of DCE
3rdQ 94	Review acceptance of Sunsoft ONC$^+$ by user community and implementation on non-Sun platforms
3rdQ 94	Track progress of Novell within a heterogeneous distributed environment.
3rdQ 94	Track DCE progress. Expect to see DCE implemented in a significant majority of heterogeneous, distributed Enterprise architecture foundations and we would also expect to see DCE connectivity Software for Netware, Apple, IBM AS/400s & Mainframes, PC platforms arriving.
3rdQ 94	Obtain and examine market share data to determine acceptance of DCE within the end-user community.
3rdQ 94	Announce release of DCE Version 1.1
3rdQ 94	Republish DCE Migration and Third Party COTS Studies
	Track progress of Microsoft NT across multiple platforms/OS's
3rdQ 95	Track progress of Novell within a heterogeneous distributed environment. Expect migration from Novell to DCE
3rdQ 95	Review acceptance of Sunsoft ONC$^+$ by user community and implementation on non-Sun platforms Expect migration from ONC$^+$ to DCE.
3rdQ 95	Obtain and examine market share data to determine acceptance of DCE within the end-user community. We would expect to see implementations beginning in many large enterprises.
3rdQ 95	Republish DCE Migration and Third Party COTS Studies

Abbreviations and Acronyms

ACL	Access Control List
API	Application Programming Interfaces
CAE	Common Applications Environment
CDS	Cell Directory Services
CORBA	Common Object Request Broker Architecture
COSE	Common Open Software Environment
DCE	Distributed Computing Environment
DEC	Digital Equipment Corp.
DFS	Distributed File Service
DTS	Distributed Time Services
DME	Distributed Management Environment
DOE	Distributed Objects Everywhere
DS	Directory Services
DSOM	Distributed System Object Management
ECS	EOSDIS Core System
GDS	Global Directory Services
GUI	Graphic User Interface
HHOG	Hilton Head Object Group
HP	Hewlett Packard Co.
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IDL	Interface Definition Language
ISO	International Standards Organization
IT	Information Technology
LAN	local Area Networks
NFS	Network File System
NM	Network Management
NSI	Name Service Interface
NT	New Technology

OLE	Object Linking and Embedding
OLTP	On-Line Transaction Processing
ONC	Open Network Computing
OSI	Open Systems Interconnect
OMG	Object Management Group
OMNIPoint	Open Management Interoperability Point
OSF	Open Software Foundation
NOS	Network Operating System
PC	personal computer
PDR	preliminary design review
PEB	Performance Evaluation Board
PICS	procurement and inventory control system
PM	preventative maintenance
PMS	Performance Measurement System
POSIX	Portable Operating System Interface (Unix)
RPC	Remote Procedure Call
SCO	Santa Cruz Operation
SIG	Special Interest Group
SMP	Symmetric Multiprocessing
SNI	Siemens Nixdorf Information Systems
SNMP	Simple Network Management Protocol
UDP/IP	User Datagram Protocol/Internet Protocol
UI	Unix International
USL	Unix Systems Laboratories
UUID	Universal Unique Identifier
XDS	X/Open directory service
XOM	X/Open Object Management
XPG	X/Open Portability Guide